OBSERVATIONS ON THE GROWTH RATE OF THE FOOT IN THE MOUND BIRDS OF THE GENUS MEGAPODIUS

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Among terrestrial birds the feet are generally relatively larger or more powerfully developed than in comparable arboreal forms, but there are few carinate birds with larger, more powerful feet than the megapodes. The unusual development of the feet in this group has been assumed to be correlated with their scratching habits, especially in making the mounds of decaying matter or in excavating the holes in the sand, as the case may be, in which they lay their eggs. Certainly few birds, even those that burrow in the ground, have more need of large, strong feet than the megapodes. In this family of birds, however, the case is somewhat different from that obtaining in other groups in that not only do the adults use their feet in digging, but the young have to dig their way up to the surface on hatching. In no other group of birds do the newly hatched young have such immediate need of strong feet. Consequently it seemed that a study of the feet of young and adult birds might show something of interest in helping to understand some fragment of the puzzles that the life histories of the megapodes present.

Recently the United States National Museum received a fine series of alcoholic specimens of *Megapodius pritchardi* collected by Lieut. Henry C. Kellers, United States Navy, on Niuafou Island, one of the Tonga group. Among these there were two chicks and one embryo nearly ready to hatch, as well as a large number of adults of both sexes. The embryo is remarkable in that while it is in a stage of development close to hatching and has the pennaceous juvenal plumage well developed, although still encased in sheaths like the trichoptiles of cuculiform birds, it has no sign of an egg tooth. Incidentally, it seems that the extent of prehatching development in the megapodes is not generally appreciated. Whereas in most precocial birds, such as pheasants and ducks, the young are hatched fully covered with natal down, in the megapodes this plumage stage seems to be entirely telescoped into the period before hatching, and

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67977—31

the young birds when emerging from the egg are in the first pennaceous, or juvenal, plumage. Pycraft[1] has noted this, but his paper has been largely overlooked by ornithologists.

The embryo has the following dimensions, in millimeters (the sizes of the culmen and wings are included as a scale by which to compare the embryo, the chicks, and the adults): Culmen, 11; wing, 74; tarsus, 28; first toe (without claw), 16; claw, 8; second toe, 16.5; claw, 8; third toe, 14.5; claw, 8; fourth toe, 11; claw, 7.5.

The two chicks are alike in their dimensions (millimeters): Culmen, 11; wing, 82; tarsus, 28; first toe, 16; claw, 8.5; second toe, 17; claw, 8.5; third toe, 15; claw, 8.5; fourth toe, 11; claw, 8.

Adults vary as follows (millimeters): Culmen, 22–26 (average, 24); wing, 178–192 (185); tarsus, 56–60 (58); first toe, 30; claw, 18; second toe, 31.5; claw, 19; third toe, 30; claw, 18; fourth toe, 23; claw, 18.5.

To summarize these data: The wing increases from 82 to 185 mm., an increase of approximately 126 per cent; the culmen grows from 11 to 24 mm., an increase of 118 per cent; the tarsus increases from 28 to 58 mm., a growth of 107 per cent; the first toe from 16 to 30 mm., an increase of 87.5 per cent; claw from 8 to 18 mm., an increase of 125 per cent; second toe from 16.5 to 31.5 mm., an increase of 91 per cent; claw from 8 to 19 mm., an increase of 137.5 per cent; third toe from 14.5 to 30 mm., an increase of 107 per cent; claw from 8 to 18 mm., an increase of 125 per cent; fourth toe from 11 to 23 mm., an increase of 109 per cent; claw from 7.5 to 18.5 mm., an increase of 147 per cent.

As a matter of comparison, chicks and adults of *Gallus sonnerati*, as an example of the pheasants, and of *Tinamus robustus*, as a representative of the tinamous (two fairly related groups), were examined, with the following results: In *Gallus sonnerati*, the culmen was found to increase by 56 per cent; the wings of the young chicks being unfortunately in poor condition, the wing growth could not be estimated; the tarsus increased by 114 per cent; the first toe by 26 per cent; the second toe by 37 per cent; the third toe by 32.5 per cent; the fourth toe by 13 per cent; the claws by 10 to 25 per cent. In *Tinamus robustus* again no wing data could be obtained; the culmen increased by 130 per cent; the tarsus by 129 per cent; the first toe by 95 per cent; the second toe by 85 per cent; the third toe by 85 per cent; the fourth toe by only 35 per cent. The claws increased by about 300 per cent.

On looking over these figures we may note that the megapodes show a much greater postnatal development of the claws than *Gallus* and much less than *Tinamus;* they show a greater growth of the toes

[1] Proc. Fourth Internat. Ornith. Congr., p. 458, 1907.

generally than does *Gallus* and slightly more than in *Tinamus;* they show less postnatal development of the tarsus than in either of the latter two. To put it another way: The young megapode, on hatching, has a rather unusually strong, well-developed tarsus, but not particularly large or heavily built toes or claws relative to its size as compared with adult birds. It has larger claws at all stages than do the pheasants or tinamous. The inference to be drawn from these few data (it is hoped they will be greatly extended by others with more abundant material) seems to be as follows: Adult megapodes are built for digging and excavating with their feet; young ones are not structurally adapted to digging themselves out except in having the tarsus unusually large. In other words, the digging is a matter of the tarsus in the young, while in the adults it seems to be more a matter of toes and claws. The mechanical advantage is greatly in favor of the adults.

This appears to be correlated with the difference in the sort of digging the young and old birds have to do. In digging down from the surface the old birds can scratch and shovel away the dirt, ash, or sand in all directions, and in such digging large, strong toes with big, heavy claws are of great service. The young birds, however, interred in the ash, sand, or mound, have to dig their way out; here the type of digging is more like an upward boring without the wide lateral spread possible in the adults' digging. For this type of work large toes with long, strong claws would be more of a hindrance than a help. The final conclusion to be drawn from the meager data available is that the premature development of the tarsus in the young bird up to the point of hatching is a feature that may readily be correlated with the peculiar breeding habits of the megapodes.

I have dissected the legs of young and old megapodes and find there is no difference in the arrangement or relative strength of the tendons and muscles working the toes.

The suggestion that the manner in which the young megapode digs itself out is like an upward boring is substantiated indirectly by Ashby's notes on the Australian megapode *Leipoa ocellata.*[2]

He writes of a newly hatched chick as follows:

> It had hatched out and after being dried by the hot sand surrounding it, had scrambled up through the mound; by the mark where it had emerged the course taken was almost perpendicular.

Inasmuch as *Megapodius pritchardi* is confined to the small and seldom visited island of Niuafou and has been collected only a few times, little has been recorded of it. It is one of the species that buries its eggs in the sand and volcanic ash and does not make large

[2] Auk, vol. 46, pp. 299, 300, 1929.

In the fifteenth parapodium the dorsal and ventral cirri are relatively much smaller and more slender, and the parapodial lobe is heavy and blunt pointed. (Fig. 1, *c*.) The dorsal lobe is now double and the seta tuft arises between the two parts. A single large acicula occurs in each part of the parapodium. In parapodia from the posterior part of the body the dorsal half of the upper parapodial lobe is, relatively to the others, much larger and bears the slender dorsal cirrus near its apex. The ventral cirrus is small and inconspicuous. (Fig. 1, *d*.) In the first parapodium the setae

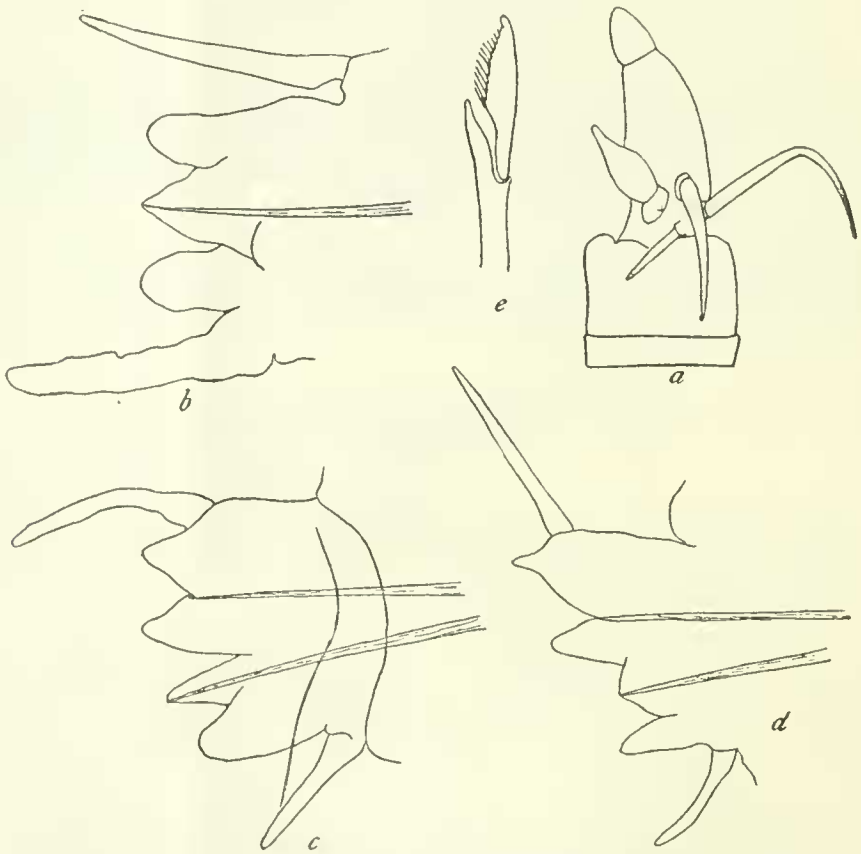

FIGURE 1.—*Nereis heterocirrata*, new species: *a*, Head, × 7.5; *b*, first parapodium, × 18; *c*, fifteenth parapodium, × 36; *d*, posterior parapodium, × 27.5; *e*, seta from first parapodium, × 250

on the ventral part of the seta tuft have short terminal joints that carry long, heavy spines on the inner margins (fig. 1, *e*); those of the dorsal tuft have long and slender terminal joints, and these are finely toothed along one margin. In the posterior portions of the body the seta are badly broken, but so far as it is possible to tell both of the above varieties occur there. In addition are some with much more slender, noticeably "camerated" shafts, the terminal joints flat, elongated triangular in outline, with prominent marginal spines.

Type.—U.S.N.M. No. 19323.